Space Weather Technical Forecast

Issued on Saturday, 13 May 2023 at 01:15 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Slight Chance of further G1 over UTC weekend. Chance of R1/R2 radio blackouts decreasing slightly into new week.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity reverted to Low in the past 24 hours, with X-rays recorded at GOES16 showing occasional C-class activity and peaking with a long-period C5.6 at 12/1336UTC, and a rising C5.7 at 12/2359UTC from AR3296 on the northwestern limb. This event was associated with a Coronal Mass Ejection (CME) that does not carry an Earth-directed component. The sunspot group responsible was one of up to nine on the disc for a time, although AR3303 faded to plage in the southeast over the period. Sunspot region AR3296 is now becoming difficult to discern near the limb, however it appears as a Dai/Beta-Gamma, with apparent penumbral decay, but also by contrast some trailing spot development. Most of the other sunspot regions were quiet or in slow decay, however there was some proliferation of spots in AR3303 and 3305, while AR3302 perhaps contains a tenuous candidate for a mount Wilson delta spot in its trailing group.

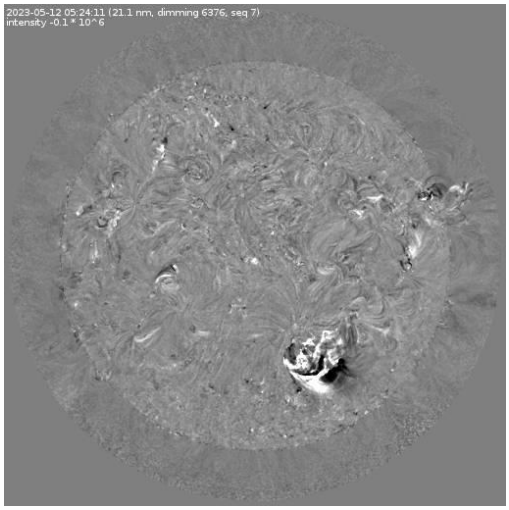


Figure 0a: Time-integrated AIA211 image of 12/0500UTC filament eruption. Image processing courtesy of SIDC ROB.

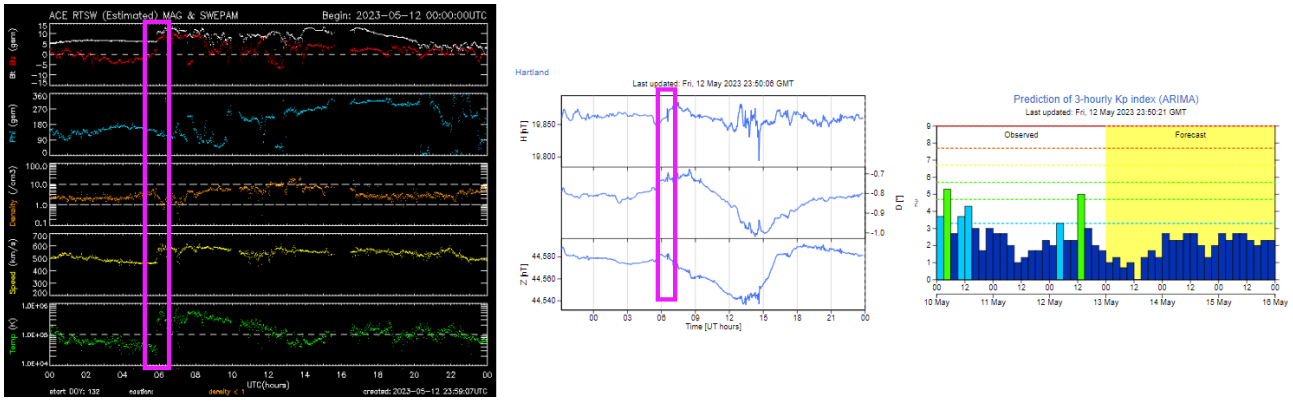
A filament eruption was seen in the southwestern quadrant on Learmonth H-alpha imagery around 12/0500UTC. A narrow CME was seen heading largely south and west of the Sun-Earth line - this has been analysed and modelling results are awaited. There were other CMEs observed in imagery, including from behind the northeastern limb, which may herald the arrival of a new active region, while a partial halo heading south and west later in the UTC afternoon was determined to be far-sided.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, was

© Crown Copyright 2023. All Rights Reserved.

suggestive of a CME arrival - presumed to be that from 09 May. A sharp discontinuity was seen at 12/0549UTC in most solar wind measures, with the speed rising sharply from a previous decline from 550 to 475km/s to reach 575, with an erratic decline then re-establishing for the remainder of the period to reach 525km/s. The solar wind density was mostly Slightly Elevated, with a rise after the CME onset to a peak of 25ppcc before a decline into the UTC evening. The IMF was similarly Slightly Elevated after the CME onset, with a peak of 14nT observed, however the north-south component showed a fairly strong co-aligned bias (with Earth's field) to somewhat limit geomagnetic effects, with a range of +13 and -7nT. The phi angle started the period orientated largely away from the Sun (positive), but transitioned to be mainly towards through the UTC afternoon and evening.

Figure 0b: ACE L1 solar wind measures, showing the 09 May CME arrival boxed in magenta, with subsequent arrival at Hartland magnetometer shown (centre) and resultant geomagnetic activity (right).


ACE RTSW (Estimated) MAG & SWEPAM
Begin: 2023-05-12 00:00:00UTC
Hartland
Last updated: Fri, 12 May 2023 23:50:06 GMT
Prediction of 3-hourly Kp index (ARIMA)
Last updated: Fri, 12 May 2023 23:50:21 GMT
Observed
Forecast

The net result of the above solar wind measures was for Quiet to Minor Geomagnetic Storm G1 intervals, with the provisional peak Kp of '5o' in the 12-15UTC interval coinciding with an anti-aligned Bz component while the solar wind speed and density were still enhanced.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as measured at GOES16 very soon settled to its typical Background level in the period.

High energy electron flux (greater than 2MeV), as measured at GOES16, has varied between Normal Background and Moderate levels on a diurnal trend, with a peak of 592pfu seen at 12/1250UTC.

The 24-hour integrated fluence has been well below Active levels, with a near-level tendency. At 13/0001UTC, 1.19e7 integrated pfu was recorded.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity carries a Chance of returning to Moderate, with this risk greatest over the current UTC weekend while AR3296 remains on the disc, else tentatively falling a little into the new working week, with no major returning regions expected.

Solar Wind / Geomagnetic Activity: The 09 May full halo CME arrived at Earth around 12/0634UTC and has now largely passed, with the solar wind speed now in decline. A further CME was observed following the M2.1 flare that occurred on 11 May in the southwest quadrant. It may glance the Earth on 14 into 15 May, but with very low confidence. Thirdly and finally, any Earth-directed component from the 12/0500UTC filament is not yet known, with modelling results pending.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

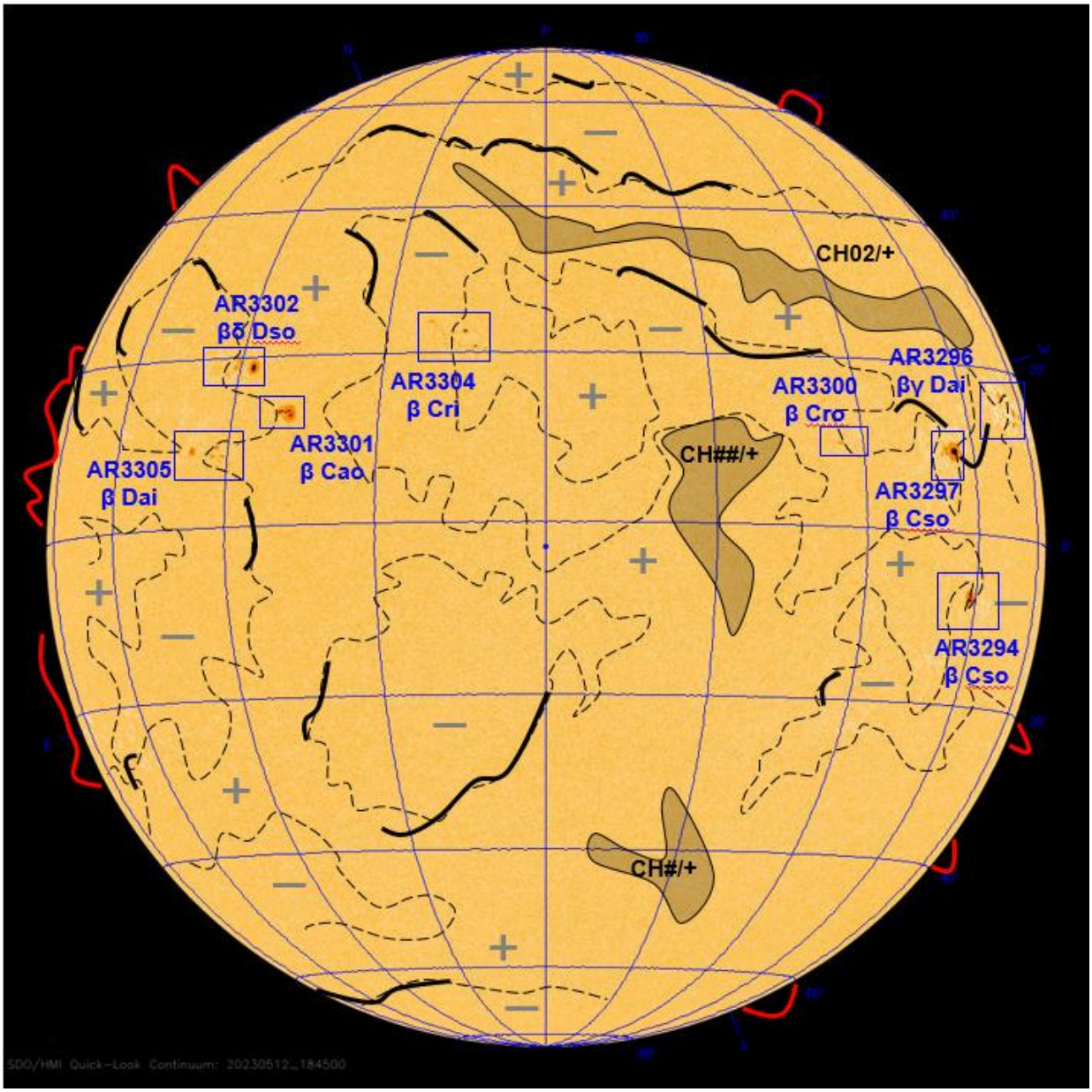
© Crown Copyright 2023. All Rights Reserved.

With little on the disc coronal hole-wise, the above (confirmed) CMEs should deliver a decreasing Slight Chance of G1 over the first three days of the period, with an increasingly Quiet forecast otherwise expected.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux now carries a daily Slight Chance of S1, decreasing slightly into the new working week as the main sunspot responsible for this risk crosses the limb and rotates away.

High energy (greater than 2MeV) electron flux is expected to persist at Normal Background to Moderate levels. The associated 24-hour fluence is forecast to persist below the Active threshold.

Figure 1. Solar Analysis Valid 12/1845UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Met Office Space Weather Technical Forecast

Geomagnetic Storms:

The full halo CME which left the Sun late on 09 May passed L1 at 12/0549UTC and subsequently registered at Earth on BGS magnetometers with a 20nT deflection in Hartland's H-component at 12/0634UTC. The CME came in largely co-aligned with Earth's magnetic field to limit its effects, and failed to evolve fully into a magnetic-cloud like signature with time, perhaps implying Earth was only affected by the sheath. A G1 interval was observed in the 12-15UTC interval however during a relatively breif negative Bz period, implying that the event was capable of significant activity, even if it fortunately arrived is a favourable orientation. The passing of this event has greatly reduced the likelihood of further geomagnetic activity in the four-day period.

A further CME was observed following the M2.1 flare that occurred on 11 May in the southwestern quadrant. The latest MOSWOC Enlil model has its deterministic run as a near miss, passing 1AU around the turn of the UTC day of 14 into 15 May. Some of the MOSWOC Enlil ensemble members do however show a weak glance late on 14 May, which may perhaps continue into the 15 May, but with very low confidence.

Finally in terms of transients, the southwest quadrant filament eruption from 12/0500UTC has been submitted for modelling, but results are not yet in to determine any Earth-directed component. This may feature on the G1 probabilities into the new working week in future issues of this guidance.

The persistence forecast is expected to show little impact from high latitude coronal hole 02, with two unnumbered features near the solar equator and in the southwestern quadrant offering an uncertain but likely limited contribution to any fast wind in the period, with increasingly Quiet conditions otherwise now expected.

All considered, the drivers of the geomagnetic forecast are likely to be weak transients rather than coronal holes in the period, with a residual Slight Chance of G1 from the tail of the 09 May CME, giving way to a further Slight Chance of G1 from the 11 May CME, partitioned between the UTC days of 14 and 15 May. The geomagnetic forecast should otherwise become increasingly Quiet.

Geo-Magnetic Storm / **Probability (Exceedance)**	**Level**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)** (%)	**Day 2 (00-24 UTC)** (%)	**Day 3 (00-24 UTC)** (%)	**Day 4 (00-24 UTC)** (%)
Minor or Moderate	**G1 to G2**	Yes	20	10	10	1
Strong	**G3**	No	1	1	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

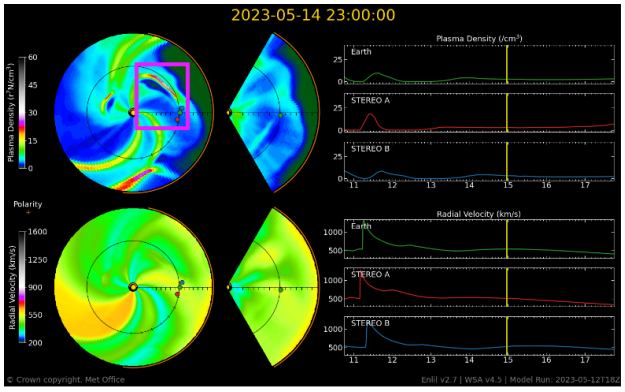
Geomagnetic Activity - Earthbound Coronal Mass Ejections

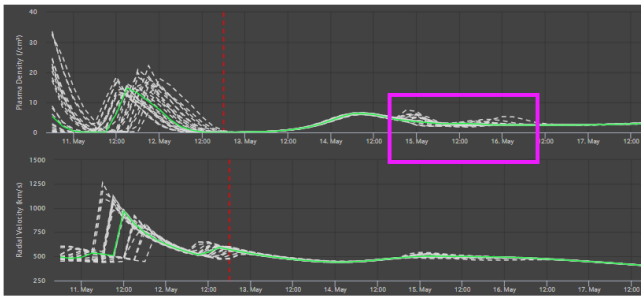
Currenty nil, but near miss possible in UTC day 14 into 15 May and a further candidate from 12/0500UTC undergoing assessment.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 2: Latest MOSWOC Enlil run and ensemble, showing boxed magenta the 11 May CME with some minor glances in the ensemble but a deterministic miss.





Radio Blackouts - X-Ray Flares:

There were nine sunspot regions on the Earth-facing disc for a time in the past 24 hours, however AR3303 faded to plage. The most significant region remains AR3296, as although it appeared to show a decrease in penumbral area in the period, it managed to develop some low latitude sunspots to hint at preserved activity here, even as most other regions on the disc showed the opposite trend in slowly fading.

Other exceptions to the generally fading current cohort of spots were AR3304 and AR3305 in the northeast, with both showing slight proliferation, while AR3302 showed a candidate for a weak mount Wilson delta spot in its trailing group, which is something to be monitored. Overall, the Sun seems to be entering a episodic lull in activity, with the Penticton 10.7cm flux falling from a midweek high of 180sfu on 09 May to reach 149sfu on 12 May.

There appears to be little expected in terms of returning Carringtons for sunspot regions in the period, however a northeastern limb CME in the past 24 hours may hint at a region here, although it is at least a day away from the front side judging by its apparent absence from the latest available STEREO A EUVI 195 imagery.

The outlook for X-ray activity is therefore tentatively a slight step-wise decrease as AR3296 departs early on day two, Sunday 14 May, however given the sheer number of sunspot groups, confidence in this assertion is low, and a resurgence in activity could occur at any time.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**R1-R2 M Class**	No	40	40	30	30
Very Active	**R3 to R5 X Class**	No	5	5	5	5

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

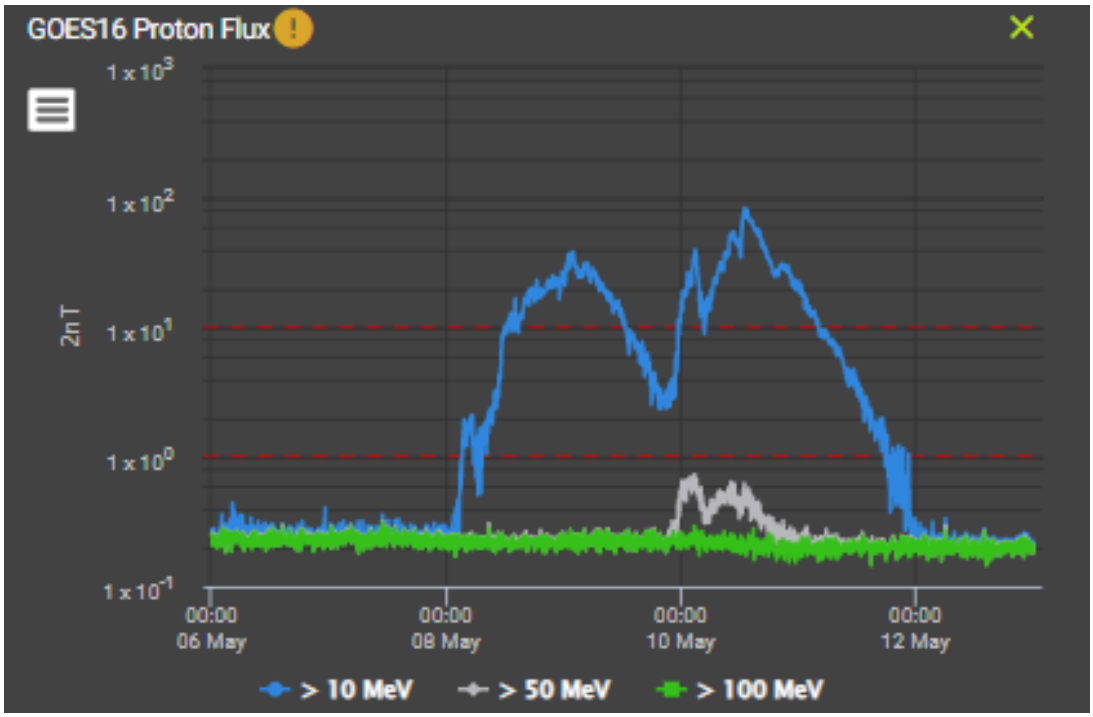
Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16 soon settled to its resting Background into the start of this 24-hour period, and is now therefore comfortably below the S1/Minor Storm threshold.

The most likely source for generating S1 events is now nearing the most reliably-connecting sector of the Sun (with Earth), should a suitable flare and solar radiation storm arise. The probabilities of S1 events are therefore held slightly above the raw risk for the disc, especially given AR3296 is now difficult to fully analyse given limb foreshortening effects. The risk should very gradually ease into the new UTC working week as this spot rotates from this potent position.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	20	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 3: Past week in GOES16 high energy protons, showing some S1-level enhancement from activity in AR3296 especially, which is now nearing the western solar horizon.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2MeV) appears to have reached an equilibrium state between Normal Background and Moderate flux given the modest geomagnetic interruption from the 09 May CME. This feature has now passed, and with little on the disc to cause a significant solar wind speed enhancement, electron flux and fluence ought to remain below Active throughout, with increasing uncertainty later in the period due to the tenuous appearance of (unnumbered) possibly geoeffective coronal holes near the solar equator and in the southwestern quadrant.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	5	10	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.